



INSTRUCTIONS

TESTING INFORMATION

INTRODUCTION

This section covers the electrical components used on board the locomotive. The information includes the drawing symbol and designation shown on electrical schematic diagrams, a pictorial view of the component and a brief description and use of the component.

The intent of this section is to provide an overall listing of the electrical components to serve as a definitive reference for the maintainer as a further aid during trouble-shooting and testing.

ELECTRICAL COMPONENTS

The material in Table XIII-I has been compiled to include the electrical components used in transportation equipment. In order to achieve the convenient size and specific type of coverage desired, many nonapplicable items have been omitted. The subject material, therefore, pertains only to those electrical components whose symbols appear on circuit diagrams and schematics. Whenever possible, the electrical components have been presented in alphabetical order; however, symbols having similar or converse meanings are grouped together for convenience.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.

XIII

TABLE XIII-I, ELECTRICAL COMPONENTS

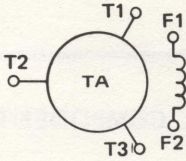
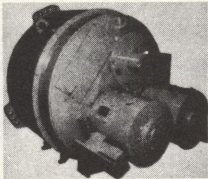
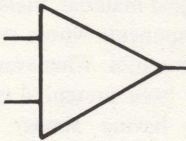
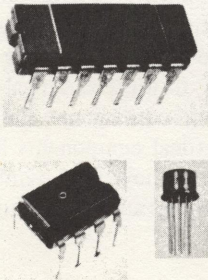
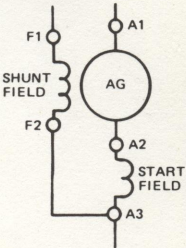
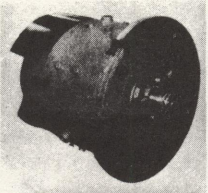
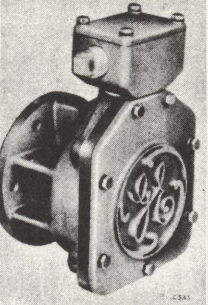
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
ALTERNATOR, TRACTION 		TA	The traction alternator is a three-phase a-c generator that provides electric propulsion power for locomotives. The output is rectified and used to power the d-c traction motors geared to the wheels.
AMPLIFIER, OPERATIONAL 		OA1, OA2, or IC1, IC2, etc.	An integrated circuit module which can be used as a voltage amplifier, current amplifier, ramp generator, comparator, voltage detector and oscillator.
AUXILIARY GENERATOR, ALTERNATOR EXCITER 		AG, EXC	Both units are d-c generators mechanically connected to the traction alternator (or generator). The exciter supplies power for alternator (or generator) excitation and the auxiliary generator is used for battery-charging and lighting.
AXLE ALTERNATOR 		AA, ALT	These alternators are single-phase a-c generators driven by the locomotive axles. The outputs are used to detect wheel-slips or slides, then initiate corrective action.

TABLE XIII-I (Cont'd.)

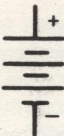
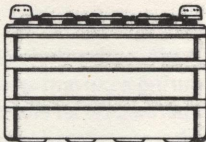
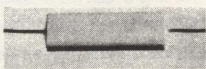
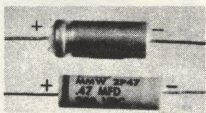
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
BATTERY 		BATT	Series-connected cells provide d-c power to locomotive circuits.
BELL 		None	A high-intensity electric bell is frequently used in the locomotive cab to signal a wheelslip condition or provide a warning of no battery charge.
CAPACITORS FIXED, NON-POLARIZED  FIXED, POLARIZED  	  	C1, C2, C3, etc.	Capacitors perform the following circuit functions: 1. Blocks the flow of dc but permits ac to flow through the circuits. 2. Bypassing; allows ac to take an easy path around a circuit in which ac is undesirable. 3. Filters and smooths out ripple in power supplies. 4. Feedback; applies some of a circuit's output into the input (in phase) to strengthen and regenerate the signal, or (out of phase) to weaken the signal.

TABLE XIII-I (Cont'd.)

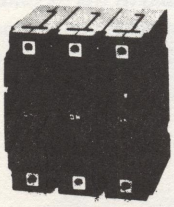
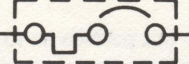
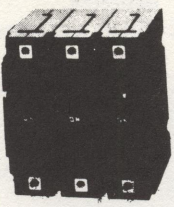
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
CIRCUIT BREAKERS Instant Trip 	 	B, CB, CCB, CSB, HLB, RCB, etc.	A protective device which opens a circuit during a current-overload condition. It operates on an electromagnetic principle whereby excessive current generates excessive electromagnetic force which, in turn, trips the breaker. This breaker responds very quickly to a current-overload condition. It must be reset manually following a trip.
Thermal Trip 	 	B, CB, CCB, CSB, HLB, RCB, etc.	A protective device which opens a circuit during a current-overload condition. It operates on a thermal-overload principle whereby excessive current generates excessive heat which, in turn, trips the breaker. This breaker has a delayed response to a current-overload condition, since it requires time to heat the trip mechanism. It must be reset manually following a trip.
DIODES			CAUTION: As most diodes are polarity-sensitive, correct polarity must be considered when using a diode in an electrical circuit. The application of voltage with the polarity reversed may damage the diode. NOTE: Polarity of the diode may be identified by a band around its cathode end, a diode symbol, or color coded leads.

TABLE XIII-I (Cont'd.)

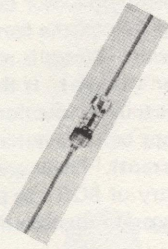
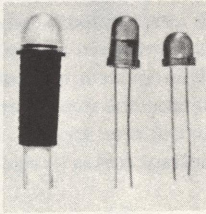
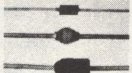
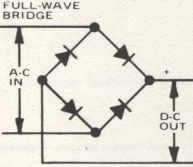
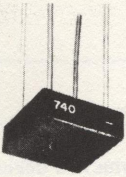
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
DIODES (Cont'd.) Current Regulator (Current Limiting) 		CLD1, CLD2, D1, D2, etc.	A semiconductor device which conducts a limited amount of current in one direction and blocks current in the opposite direction; used when a constant current is required from a changing voltage.
Light-Emitting (LED) 		LED1, LED2, etc.	Light-emitting diodes (LED's) produce a dull glow when they pass current. LED's are also polarity-sensitive and will not illuminate if their voltage polarity is reversed. They are used on control cards to indicate the presence of supply voltages; i.e. +15 vdc -15 vdc, etc. CAUTION: LED's require a specific amount of current to function properly. The application of voltage directly to an LED without a current-limiting resistor will burn it out.
Signal and Rectifier 	 	D1, D2, or RD1, RD2, etc.	A semiconductor device which conducts current in one direction and blocks current in the opposite direction; used for half-wave rectification in a-c circuits.
		RT1, RT2, or RB1, RB2, etc.	Configuration of diodes that rectifies both half-cycles of alternating current; frequently packaged as a single unit, with four pins extending from case.

TABLE XIII-I (Cont'd.)

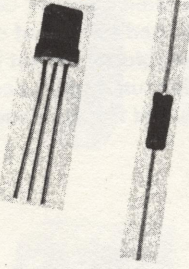
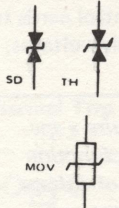
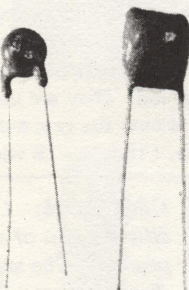
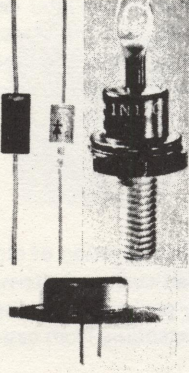
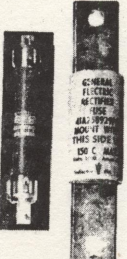
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
DIODES (Cont'd.) Silicon Unilateral Switches and Shockley 		SUS1, SUS2, etc.	A semiconductor device which blocks current flow in the forward direction until a specific voltage is reached (Forward Break-over Voltage). It then conducts and remains in conduction until its current flow drops below a minimum value (Holding Current). These are used in the gate circuitry of SCR's to prevent the SCR's from triggering (conducting) due to noise.
Suppressor, Thyrector and Metal Oxide Varistors 		SD1, SD2, THR1, THR2, MOV1, MOV2, etc.	A semiconductor device which conducts current when a specific voltage is exceeded. This device is not polarity-sensitive and retains the same characteristics, regardless of polarity applied. It is used to reduce voltage spikes in electrical circuits.
Zener and Reference 		ZD1, ZD2, etc.	A semiconductor device which conducts current when a specific reverse voltage is exceeded. This device normally operates with a positive voltage applied to its cathode. The voltage across the zener or reference diode remains nearly constant over its current range. It is used for regulating voltages in electronic circuits.
FUSE 		FU1, FU2, etc.	A protective device which opens a circuit during a current-overload condition. A fuse contains a strip of low-melting-point metal which burns out then opens a circuit during a current-overload condition. A fuse must be replaced after it burns open.

TABLE XIII-I (Cont'd.)

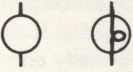
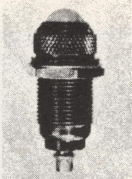
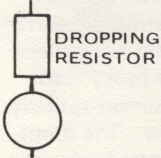
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
LAMPS			
Illumination 		Designated by location; left rear, right front, etc.	Incandescent lamps are used for both illumination and indication. Specific groups of lamps are protected by a circuit breaker.
Indicators  B-BLUE R-RED G-GREEN A-AMBER W-WHITE Y-YELLOW		Designated by lens color in a control panel.	
Low-Voltage Lamp 		Gage lights: GL1, GL2, GL3, etc.	Lamp power is provided by the locomotive battery (75 vdc). The low-voltage gage lights use a dropping resistor in each circuit to reduce the bus voltage (75 v) to the lamp voltage (6 v).

TABLE XIII-I (Cont'd.)

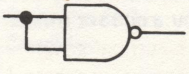
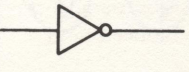
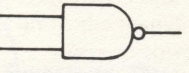
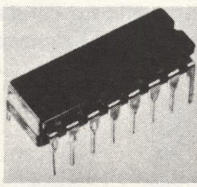
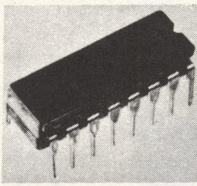
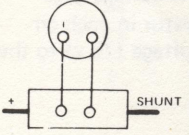
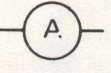
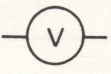
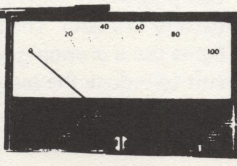
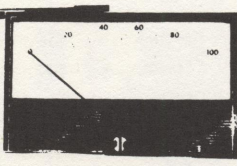
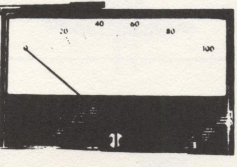
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
LOGIC GATES Inverter Gate   Nand Gate 	 	IC1, IC2, etc. IC1, IC2, etc.	An integrated-circuit module which performs inverting functions in digital logic circuits. A single module normally contains multiple circuits. An integrated-circuit module which performs nand gate functions in digital logic circuits. A single module normally contains multiple circuits.
METERS Load Ammeter  Ammeter  Voltmeter 	  	LA1, LA2, LS1, LS2, LM1, LM2, etc. A1, A2, MA1, etc. V1, V2, etc.	A typical ammeter is the load ammeter (LA) which measures d-c armature current in a traction motor. The ammeter shunt (low resistance) carries the heavy load current and only a small current actually passes through the ammeter. The shunt must be matched to the ammeter for correct meter calibration. The ammeter measures the current in an electrical circuit. The voltmeter measures the differences of potential between different points of an electrical circuit.

TABLE XIII-I (Cont'd.)

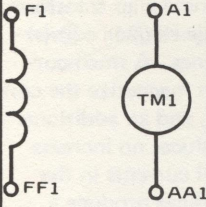
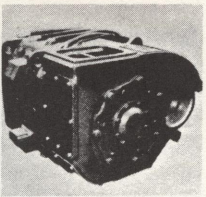
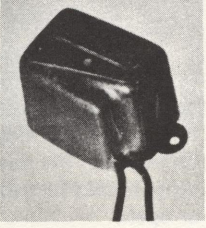
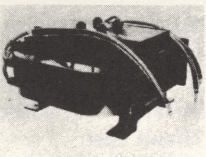
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
MOTOR Traction 		TM1, TM2, etc.	The series-wound d-c traction motors are mechanically connected to each set of drive wheels and receive electrical power from the traction alternator (or generator) or catenary. During transition, motor groups are connected in series/parallel or full parallel under full or reduced field conditions. During dynamic braking, the traction motors function as d-c generators and apply their output power into dynamic-braking grids (or resistors) to provide reverse torque to slow down the locomotive.
REACTORS Inductor, Filter, Choke 		L1, L2, L3, X1, X2, X3, etc.	Smooths out ripple in d-c signal and power circuits.
Current Measuring 		CMR1, CMR2, CMRX1, CMRX2, ACCR, etc.	A current measuring reactor (CMR) is a type of saturable reactor utilizing the magnetic flux from a high-current d-c conductor to change the current flow in its a-c winding. The a-c winding provides a signal proportional to current flow in the d-c conductor. The primary advantage of a CMR is in its ability to provide voltage isolation between its a-c signal winding and a high-voltage d-c conductor.

TABLE XIII-I (Cont'd.)

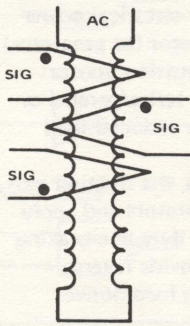
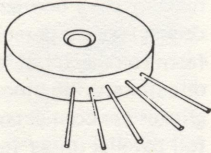
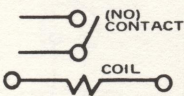
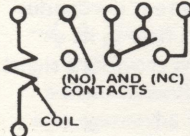
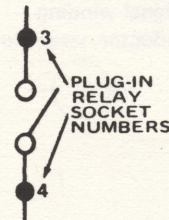
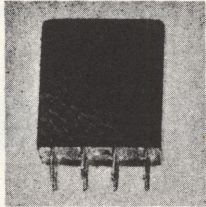
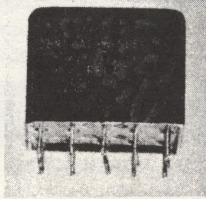
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
REACTORS (Cont'd.) Saturable Reactor 		PWM, VCR, VCBR, etc.	Saturable reactors are similar to transformers and consist of a magnetizable core(s) and two or more windings. A small current in one winding can magnetize the core completely (saturated), and an additional increase in current produces no increase in magnetic flux. Small currents in the signal (SIG) or d-c windings produce a cumulative effect (increase or decrease current) in the a-c winding for control purposes. The black dots on the SIG windings show proper d-c polarity for maximum "turn-on" effect.
RELAYS (AND CONTACTORS) Single Pole  Multipole  	 	WSR, OPR, PCR, FPR, etc.	Relays are electromechanical devices containing an electromagnetic coil which actuates contacts when a current is passed through it. The relay contacts control other circuit functions by switching close or open. Relay contacts may be normally-open (NO) or normally-closed (NC) when the coil is deenergized. Schematic diagrams show all relays in their deenergized position (coil circuit open). Socket numbers on plug-in relays are identified by a numbered dot connecting to the coil and each contact.

TABLE XIII-I (Cont'd.)

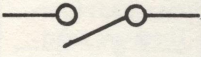
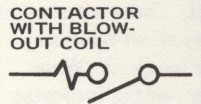
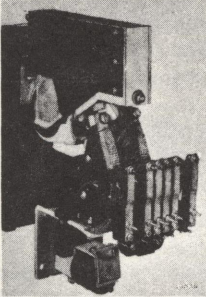
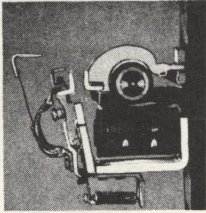
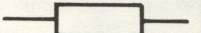
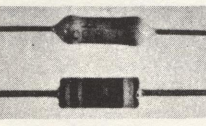
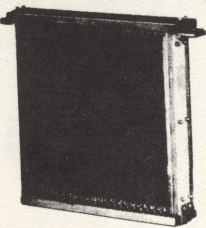
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
RELAYS (AND CONTACTORS) (Cont'd.)  	 		Contactors are devices that function similarly to relays, but their contacts are capable of carrying more current. Contactors utilize the same drawing symbols and designations as relays. A contactor may contain interlock contacts that can be adjusted to open or close before the opening or closing of its power contacts. Interlock contacts also utilize the same drawing symbols and designations as relays. CAUTION: <i>Equipment can be damaged or destroyed if interlock contacts are improperly adjusted. Check with test lights and/or buzzer to verify the interlock fingers OPEN or CLOSE before the OPENING or CLOSING of the associated main contacts.</i> A contactor also may contain a series blow-out coil to assist in arc suppression by establishing a magnetic field to oppose the magnetic field of the contact current. This causes the arc to extend and, finally, extinguish as the contacts open.
RESISTORS Fixed or Common  Power (Grid) 	 	R1, R2, etc.	Resistors limit the amount of current flow and produce a voltage drop in electrical circuits.

TABLE XIII-I (Cont'd.)

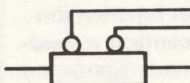
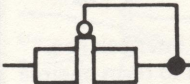
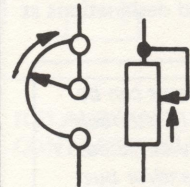
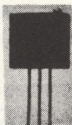
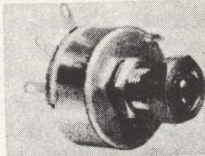
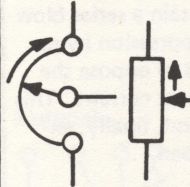
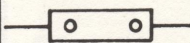
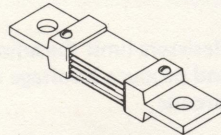
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
RESISTORS (Cont'd.)			
Tapped 		R1, R2, etc.	Tapped resistors provide one or more resistance-divider connections which function as voltage dividers. These are used where fixed voltage dividers are required.
Slider 		R1, R2, etc.	Slider resistors are variable resistors whose resistances change when the slider is repositioned; used where readjustment is seldom required.
Rheostats 	 	R1, R2, etc.	Rheostats are variable resistors with a movable wiper whose resistance changes when the wiper is repositioned. These are used in place of slider resistors when readjustment is more frequently required. When utilized, an arrow on the symbol indicates wiper movement for a clockwise rotation.
Potentiometers 	 	P1, P2, etc.	Potentiometers select a variable voltage on their movable wiper from a potential applied to their stationary terminals; used where adjustable voltage dividers are required. When utilized, an arrow on the symbol indicates wiper movement for a clockwise rotation.
Shunt 		SH1, SH2, etc.	A device that functions like a low-value resistor. A shunt measures large amounts of current by producing a small voltage directly proportional to its current flow. A shunt can measure both a-c and d-c currents.

TABLE XIII-I (Cont'd.)

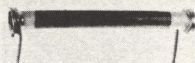
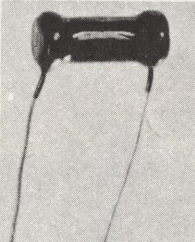
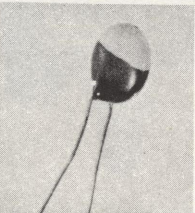
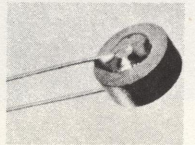
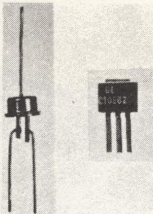
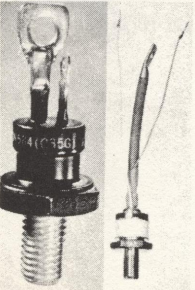
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
RESISTORS (Cont'd.) Thermistor 	   	R1, R2, R3, etc.	A variable resistor whose resistance changes with temperature. A thermistor may have a negative temperature coefficient (resistance decreases as temperature increases) or a positive temperature coefficient (resistance increases as temperature increases).
SILICON CONTROLLED RECTIFIER (SCR) 	 	SCR1, SCR2, DS1, DS2, Q1, Q2, etc.	A semiconductor device which blocks current in the forward direction until a positive voltage pulse is applied to its gate ("turn-on pulse"), then conducts and remains in conduction until its anode-to-cathode current flow drops to a minimum value ("holding current"). Turning off an SCR is normally referred to as "commutation". SCR's generally are used to control current in power circuits.

TABLE XIII-I (Cont'd.)

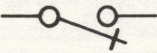
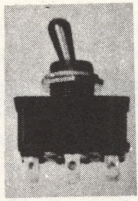
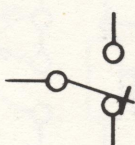
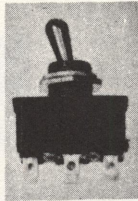
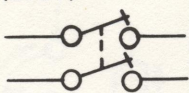
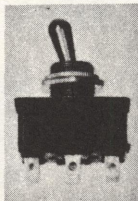
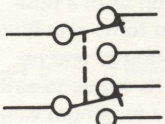
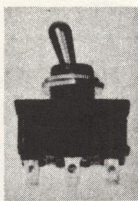
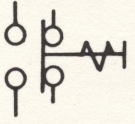
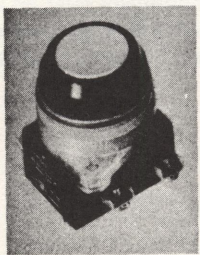
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
SWITCHES			
Single-Pole Single-Throw (SPST) 		S1, S2, S3, etc.	Mechanical devices containing manually-operated contacts which open and close to control various circuit functions.
Single-Pole Double-Throw (SPDT) 			
Double-Pole Single-Throw (DPST) 			
Double-Pole Double-Throw (DPDT) 			
Push-Button 			

TABLE XIII-I (Cont'd.)

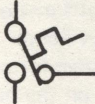
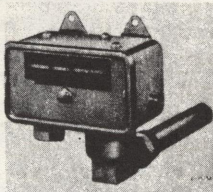
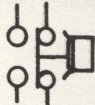
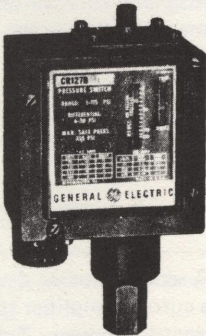
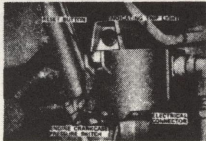
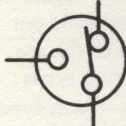
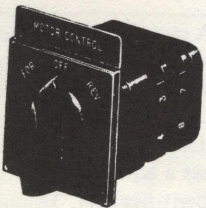
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
SWITCHES (Cont'd.) Temperature-Operated 		S1, S2, S3, or WT1, WT2, etc.	Mechanical devices containing contacts operated by temperature-sensitive, bi-metal strips.
Pressure-Operated 		PS	Mechanical devices containing contacts operated by variations in pressure of air, oil, or water.
		COP, COPS	Mechanical device with electrical contacts operated by very small variations in air pressure.
Cam-Operated 			Cam-operated switches utilize a cam on a rotating shaft to open and close switch contacts. The camshaft may be rotated manually by a switch handle or mechanically by a pilot motor.

TABLE XIII-I (Cont'd.)

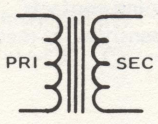
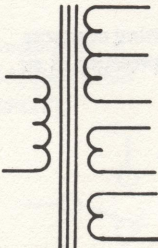
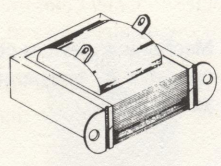
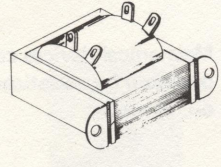
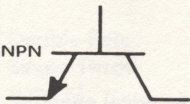
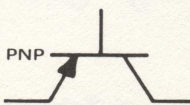
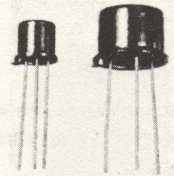
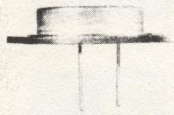
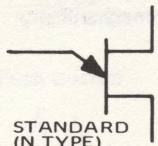
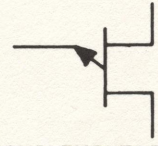
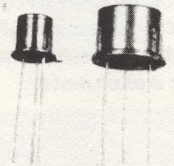
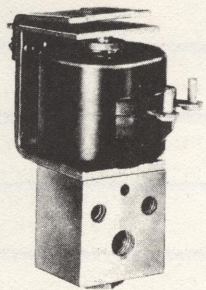
DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
TRANSFORMERS Single Winding  Multiple Winding 	 	T1, T2, T3, OST, etc.	Power transformers are used to step-up or step-down the alternating voltage received on the primary winding. A step-up transformer has a greater number of turns on the secondary winding than on the primary winding. A step-down transformer has a greater number of turns on the primary winding than on the secondary winding. All windings are insulated from the magnetic core (vertical lines), and the magnetic flux in the core operates below its saturation level.
TRANSISTORS  	 	Q1, Q2, T1, T2, FT1, etc.	A semiconductor device which operates as a current amplifier to switch and amplify electrical power. Transistors are available in two types: NPN and PNP. Each type has a separate drawing symbol, for easy identification. Transistors are utilized for general switching and amplifying applications.
TRANSISTORS, UNIUNCTION  STANDARD (N TYPE)  COMPLEMENTARY (P TYPE)		Q1, Q2, T1, T2, UJ1, UJ2, etc.	A semiconductor device which triggers on when its emitter voltage is a specific percentage of the applied interbase voltage. Unijunctions are available in two types: standard and complementary. Each type has a separate drawing symbol, for easy identification. Unijunctions are utilized primarily in oscillator and timing circuits.

TABLE XIII-I (Cont'd.)

DRAWING SYMBOL	PICTORIAL	TYPICAL DESIGNATION	DESCRIPTION AND USE
VALVES (MAGNET AND SOLENOID) 		ASMV, OSMV, ETV, RDV, SDV, etc.	An electromagnetic device which opens and closes a valve electrically to control the flow of air, oil, sand, etc. The magnet and solenoid valves are usually energized by switches or relays and are shown as a single coil on schematic diagrams.

NOTES: